NASA Aviation Safety and Security Program (AvSSP)
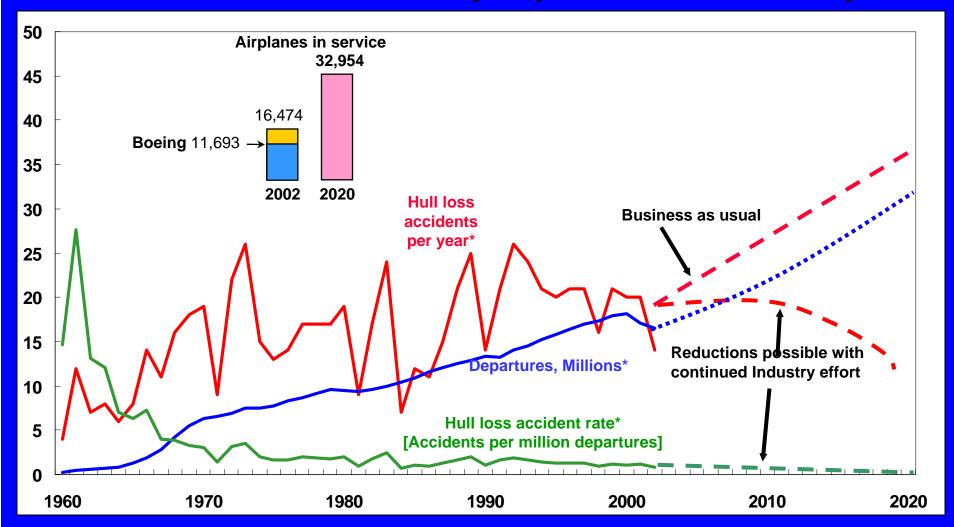
June 16, 2003
Mary F. Wadel
Project Manager, Aircraft Icing

National Challenge

We Need to Continuously Improve Aviation Safety

Airplanes in service
32,954

16,474

Boeing 11,693 →

2002　**2020**

Hull loss accidents per year*

Business as usual

Departures, Millions*

Reductions possible with continued Industry effort

Hull loss accident rate*
[Accidents per million departures]

50
45
40
35
30
25
20
15
10
5
0

1960　1970　1980　1990　2000　2010　2020

***Accident and Departure data through 31 December 2002**

5-6-03 FT-004Wc
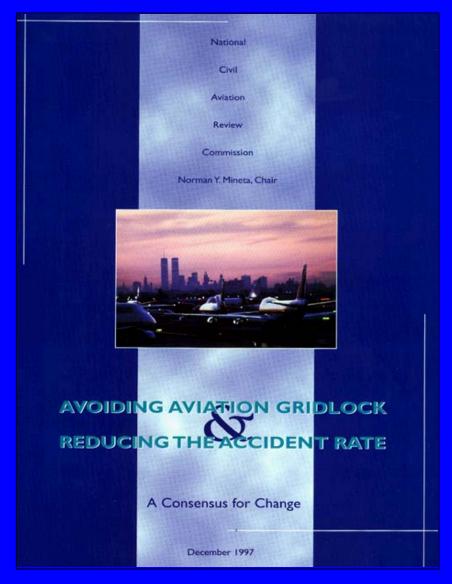
**FINAL REPORT
TO
PRESIDENT CLINTON**

**White House Commission on
Aviation Safety and Security**

★ ★ ★ ★ ★ ★ ★

VICE PRESIDENT AL GORE, CHAIRMAN

FEBRUARY 12, 1997

National
Civil
Aviation
Review
Commission

Norman Y. Mineta, Chair

**AVOIDING AVIATION GRIDLOCK
& REDUCING THE ACCIDENT RATE**

A Consensus for Change

December 1997

**"We will achieve a national goal of reducing the fatal
aircraft accident rate by 80% within 10 years."**
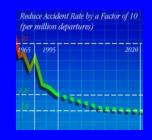*President William J. Clinton,   February 12, 1997*

AvSSP Anticipated Impacts

NASA Strategic Goal 2--Enable a *safer, more secure*, efficient, and environmentally friendly *air transportation system*.

NASA Aero Blueprint
- **Security and safety must be maintained.**

Aero Tech Theme Objective--Protect Air Travelers and the Public
Decrease the aircraft fatal accident rate and the vulnerability of the air transportation system to threats and mitigate the consequences of accidents and hostile acts.

Vehicle Safety Technologies

<u>Objective</u>: Provide Resiliency Against:
- Vehicle System/Component Failures
- Unusual Attitude Loss of Control
- Loss of Situation Awareness due to Low Visibility
- Post Crash & In-Flight Fires

<u>Accident Categories and Causes/Factors</u>:
- Loss of Control
- Controlled Flight Into Terrain (CFIT)
- Runway Incursions
- System/Component Failures

<u>Technology Focus</u>: Aircraft Vehicle Applications

Weather Safety Technologies

- <u>Objective</u>: Develop and foster the implementation of technologies that will reduce the role of atmospheric conditions (weather, including icing and turbulence) in aviation fatal accidents, incidents, and injuries.

- <u>Accident Categories and Causes/Factors</u>*:
  - Icing and other weather hazards are significant causal or major contributing factors to aviation accidents and incidents.
  - Turbulence is a contributing factor to a large number of aviation incidents involving serious passenger and crew injury.
  - Further, many CFIT and Loss-Of-Control accidents are due to weather-related crew error which could be mitigated by
    - timely, intuitive weather information in the cockpit
    - education and training aids used prior to encountering atmospheric hazards.

- <u>Technology Focus</u>: Weather decision-aiding information, avoidance, and mitigation technologies; icing design and analysis tools; and icing education and training aids for a range of GA, business, and commercial transport applications.

*[*as identified by ASIST, National Aviation Weather Initiative & Plan, CAST]*

System Safety Technologies

- <u>Objective</u>: A system-wide approach to safe operation and pro-active management of aviation safety risk, enabling a reduction in *frequency* and *severity* of undesired events.
    - Mitigation of safety risk associated with human error and human performance limitations across multiple aviation domains.
    - Development of technologies enabling continuous monitoring and identification of system-wide operational and safety trends, developing conditions, and precursor events/patterns *before* accidents occur.
- <u>Accident Categories and Causes/factors</u>
    - Human error
    - Accident precursors--known and unknown undesirable events
- <u>Technology Focus</u>: To provide reliable predictions of the system-wide effects of changes in technology, procedures, and training *before* they are introduced into the aviation system.
    - Advanced computational models of human performance within aviation contexts, improved training, improved operational and maintenance procedures, and technology product design guidelines.
    - Tools and methods which will provide air carriers, air traffic management personnel, and other air service providers with accurate, insightful, and pro-active measures of the safety, health, and performance of National Aviation System (NAS).

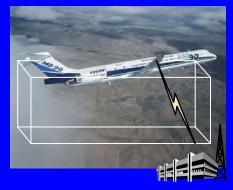# Aviation Safety and Security Program

Vehicle Safety Technologies

Synthetic Vision Systems
Make every flight the equivalent of clear-day operations

Single Aircraft Accident Prevention
Self-healing designs and "refuse-to-crash" aircraft

Accident Mitigation
Increases survivability when accidents and aviation fires occur

Weather Safety Technologies

Weather Accident Prevention
Brings intelligent weather decision-making to every cockpit

Aircraft Icing
Eliminate icing as an aviation hazard

System Safety Technologies

Aviation System Monitoring & Modeling
Monitor and assess all data from every flight for known & unknown issues

System-Wide Accident Prevention
Improves human/machine integration in design, operations, & maintenance

Aviation Security (FY 2004 Start)

Aircraft & Systems Hardening
Secure and protect the aircraft

Airspace Operation Systems
Harden the National Airspace System

Aviation Information Screening
Increase effectiveness of aviation info screening

Sensors
Integrate advanced sensors throughout the system

Synthetic Vision Systems

Worldwide Terrain, Obstacle & Airport Databases

Accurate Position & Orientation (GPS, ADAHRS)

Advanced Sensors for Database Integrity and/or Object Detection (May be too costly for GA)

Real-time tactical hazards (FIS-B, NOTAMS)

Real-time Synthetic Vision Display w/ Advanced Guidance

Relevant Traffic Information (ADS-B, TIS-B)

Assumed elements of SVS for GA applications: low-cost CPUs, displays, databases, and datalinks are possible.

Single Aircraft Accident Prevention
Self-healing designs and "refuse-to-crash" aircraft

Hazard Conditions Outside Operational Envelope
- Critical System Failure
- Adverse Conditions
- Crew Disorientation
- Invalid Control Laws

Resilient Systems for Failure/LoC Recovery

Upset

Operational Envelope
- Flight Validated
- Accurate Simulation Models
- Conventional Controls

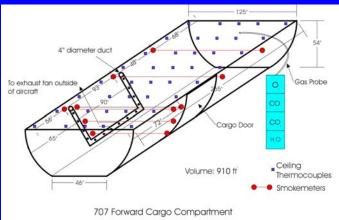**Health Management**

Loss of Control Prevention Strategy

- Health Management to prevent initiating system/component failure
- Resilient Systems to recover if a failure or loss of control does occur

Accident Mitigation

**Improved structural
modeling/prediction codes**

**Validated low false alarm fire detection
design concepts through testing and
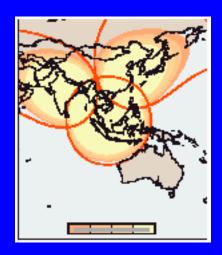analytical modeling of cargo compartment
fire signatures.**

**Validated energy absorbing structures
- subfloor and seats reduced occupant
loads by 7 to 20%**

Weather Accident Prevention

Honeywell Weather Information Network (WINN) system used in UAL In-Service Evaluation demonstrated time savings and turbulence mitigation

In-service Evaluations of Satellite Weather Information System technologies by AA on pacific rim routes demonstrated excellent SATCOM link performance at low elevation angles

Rockwell Enhanced Weather Radar (EWxR) system demonstrated the display of uplinked NEXRAD data combined with on-board radar data to provide the pilot with graphical weather information

ARNAV Weather Hazard Information system demonstrated the display of weather products in a GA cockpit

Evaluated the impact of graphic weather information on pilot decision making with the Honeywell GA tethered weather information display:

- pilot confidence same as "out the window"
- data time delay not always understood
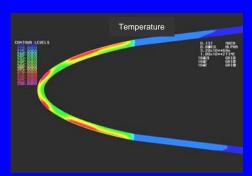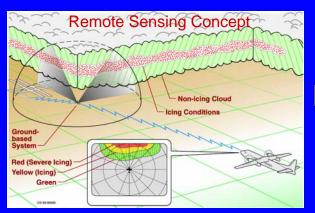- contributed to RTCA FIS-B MASPS

Aircraft Icing

Icing Design & Analysis Tools: Develop tools to accomplish better, safer designs and accurate evaluation of aircraft & aircraft sub-system performance under icing conditions for certification and qualification for flight.
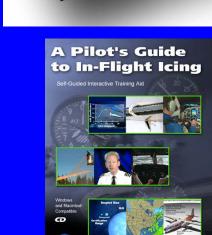
Temperature

Aircraft Ice Protection: Develop systems technologies ensuring safe flight of all aircraft in the icing environment.

Smart Icing System – Ice Management System Concept Design

Remote Sensing Concept

- Non-icing Cloud
- Icing Conditions

Ground-based System

- Red (Severe Icing)
- Yellow (Icing)
- Green

Icing Encounter

Aircraft Dynamics

Icing Effects Characterization

IPS Operation and Monitoring

Pilot / Flight Deck Automation

Envelope Protection

Control Adaptation

IMS

A Pilot's Guide to In-Flight Icing

Self-Guided Interactive Training Aid

Windows and Macintosh Compatible

Droplet Size

Certification Range

NASA Glenn Research Center

Education & Training Tools: Develop materials that support knowledge about in-flight icing on the basic concepts of icing weather, icing operations, and the impact of ice on the aircraft.

Aircraft Icing – Work Breakdown Structure

Aircraft Icing Project
Mary F. Wadel
Project Manager

Design & Analysis Tools
Mark Potapczuk
Element Manager

Aircraft Ice Protection
Andrew Reehorst
Element Manager

Education & Training
Thomas H. Bond
Element Manager

Design & Analysis Tools	Aircraft Ice Protection	Education & Training
Computational Tools	Icing Avoidance	Pilot & Operator Education
Experimental Methods	Icing Tolerant Aircraft	Engineer Education
Experimental Databases	Icing Atmospheric Characterization	Pilot & Operator Training

Aviation System Monitoring & Modeling

The People

600,000 Pilots
500,000+ Cabin Crew
17,500 Air Traffic Controllers
380,000 Maintenance Personnel

Aviation Safety Reporting System

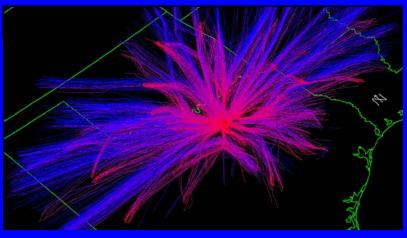National Aviation Operations Monitoring Service

The Aircraft

A320
200+ parameters/sec
X14 hrs/day
= 10,000,000 data points/day

Aviation Performance Measurement System

The System

DFW
>2500 ops/day

Nationwide
>40 million ops/yr

Performance Data Analysis and Reporting System

System-Wide Accident Prevention

Starts student learning about cockpit automation in small training airplane

Advanced portion of the training program for future airline pilots

Transitions student from small training airplane to commercial jet airliner

Iowa State University Press

Iowa State University Press (June 2001)

poc: Dr. Steve Casner
scasner@mail.arc.nasa.gov

What's on the Horizon?

Planning Strategy for New Safety Elements

FY00	**AvSP**	FY05

FY05	**New Safety**	FY10

Technology concepts developed to address current accident categories and precursors

Integration of **RETROFITABLE** AvSP technologies/ products to address changes in NAS

- **Integrated Situational Awareness System**
- **Integrated Hazard Alerting and Avoidance System**
- **Real-Time Safety Analysis Capability**
- **Immersive Flight Deck**

- **Runway Incursion Protection System**
- **Weather Information Datalink**
- **Fast-Time Simulation of System-Wide Risks**
- **Human Factors Tools**
- **Real-Time Health Monitoring Technologies**

REVOLUTIONARY technologies for all categories of aerospace vehicles operating in future airspace environment(s)

Plan for the Future

- **Continue to produce safety-enabling research products in cooperation with FAA and industry partners**
  - **Complete current Safety Projects**
  - **Plan new Safety R&D**
- **Initiate aviation security effort**
  - **Identify areas where industry or Gov't partners have need of NASA expertise**
  - **Leverage technologies from Safety to Security**
  - **Identify and address new vulnerabilities**
- **Move to risk-based assessment strategy**
- **Continue to take pro-active steps to assure technology transfer**
  - **Create joint roadmaps with FAA**
  - **Refine/create technology implementation plans**

Flight Deck

AOC

ATSP